



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/52

October/November 2021

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [].

This document has 8 pages.

- 1 A student investigates the extension of a spring supporting a wooden strip, as shown in Fig. 1.1.

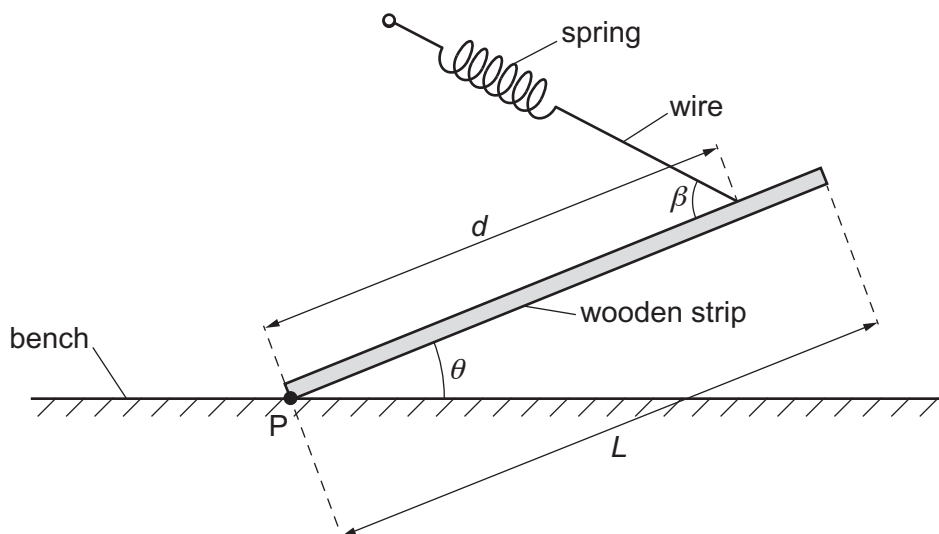


Fig. 1.1

One end of the strip is at point P. The strip has length L and is at an angle θ to the bench.

The spring is attached to the strip by a wire at a distance d from point P. The wire is at an angle β to the strip. The spring has extension x .

It is suggested that the relationship between x and θ is

$$\frac{WL}{2} \cos \theta = kxd \sin \beta$$

where k is the spring constant of the spring and W is a constant.

Design a laboratory experiment to test the relationship between x and θ .
Explain how your results could be used to determine a value for W .

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

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- 2 A Geiger–Müller (G–M) tube is a device that can detect beta-radiation. A student places paper between a radioactive source emitting beta-radiation and a G–M tube, as shown in Fig. 2.1.

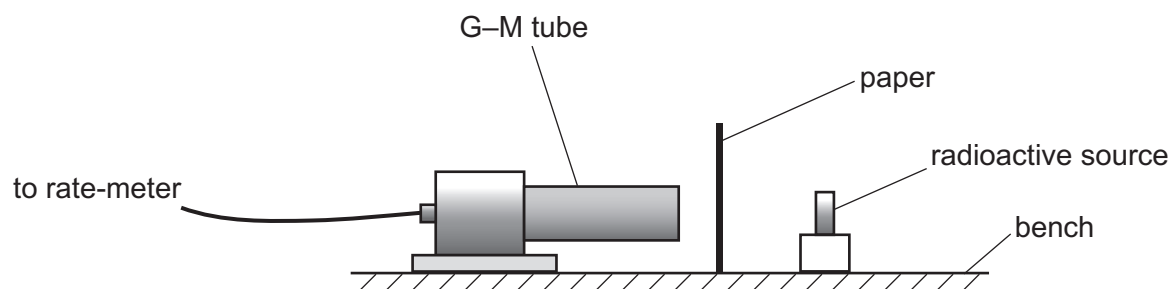


Fig. 2.1

The G–M tube is connected to a rate-meter which records the count rate R .

The thickness t of the paper is measured in two different places using a micrometer.

The student repeats the experiment for different thicknesses of paper.

It is suggested that R and t are related by the equation

$$R = R_0 e^{-\mu t}$$

where R_0 is the count rate without any paper and μ is a constant.

- (a) A graph is plotted of $\ln R$ on the y -axis against t on the x -axis.

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) The two measurements of thickness are t_1 and t_2 . Values of t_1 , t_2 and R are given in Table 2.1.

Table 2.1

t_1/mm	t_2/mm	average t/mm	R/s^{-1}	$\ln(R/\text{s}^{-1})$
0.19	0.13		47.7	
0.22	0.28		44.0	
0.39	0.45		38.2	
0.58	0.54		34.3	
0.64	0.68		31.7	
0.78	0.74		29.7	

Calculate and record values of average t/mm and $\ln(R/\text{s}^{-1})$ in Table 2.1.
Include the absolute uncertainties in average t .

[2]

(c) (i) Plot a graph of $\ln(R/\text{s}^{-1})$ against average t/mm .
Include error bars for average t .

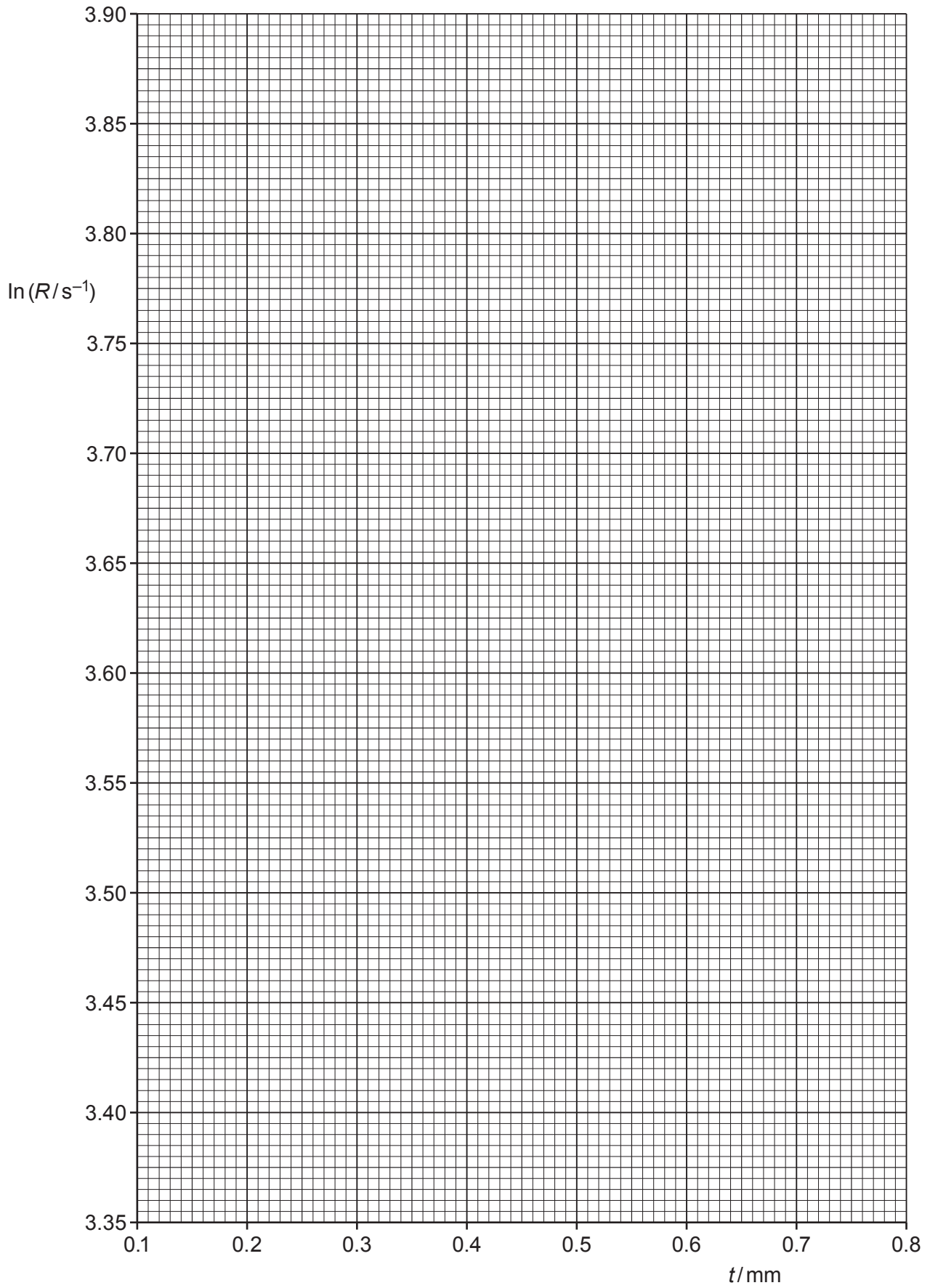
[2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled.

[2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = [2]



- (iv) Determine the y -intercept of the line of best fit. Include the absolute uncertainty in your answer.

y -intercept = [2]

- (d) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of μ and R_0 . Include the absolute uncertainties in your values and include appropriate units.

μ =

R_0 = [3]

- (e) The experiment is repeated using a different thickness of paper.

Determine the value of t that would give a value of R of 20.0 s^{-1} .

t = mm [1]

[Total: 15]

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